AL/HR-TP-1995-0004

R-WISE: A LEARNING ENVIRONMENT TO TEACH PROSE COMPOSITION

Patricia A. Carlson

HUMAN RESOURCES DIRECTORATE
TECHNICAL TRAINING RESEARCH DIVISION
7909 Lindbergh Drive
Brooks Air Force Base, Texas 78235-5352

Melinda L. Crevoisier

Command Technologies, Inc.
6852 Alamo Downs Parkway
San Antonio, Texas 78238

A
R
M
S
T
R
O
N
G

L
A
B
O
R
A
T
O
R
Y

June 1995

19960130 030

Interim Technical Paper for the Period January 1994 - July 1994

Approved for public release; distribution is unlimited.

AIR FORCE MATERIEL COMMAND
BROOKS AIR FORCE BASE, TEXAS

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This paper has been reviewed and is approved for publication.

James W Parlett
JAMES W. PARLETT, Lt Col, USAF
Chief, Intelligent Training Branch

R Bruce Gould
R. BRUCE GOULD
Technical Director
Technical Training Research Division

James B. Bushman
JAMES B. BUSHMAN, Lt Col, USAF
Chief, Technical Training Research Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
June 1995

3. REPORT TYPE AND DATES COVERED
Interim January 1994 - September 1994

4. TITLE AND SUBTITLE

R-WISE: A Learning Environment to Teach Prose Composition.

5. FUNDING NUMBERS

C -F33615-91-D-0651
PE - 66205F
PR - 1121
TA - 09
WU - 79

6. AUTHOR(S)

Patricia A. Carlson
Melinda L. Crevoisier

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Command Technologies, Inc.
6852 Alamo Downs Parkway
San Antonio TX 78238

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Armstrong Laboratory
Human Resources Directorate
Technical Training Research Division
7909 Lindbergh Dr
Brooks AFB TX 78235-5352

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

AL/HR-TP-1995-0004

11. SUPPLEMENTARY NOTES

Armstrong Laboratory Technical Monitor: Patricia A. Carlson. (210) 536-2034

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This paper describes a computerized environment for teaching the conceptual patterns of critical literacy. While the full implementation of the software covers both reading and writing, this paper discusses only the writing aspect of R-WISE (Reading and Writing in a Supportive Environment). The project is part of a seven year Air Force Effort--Fundamental Skills Training or (FST)-- to transition advanced computer-aided instruction to the public school sector. This paper gives an overview of the approach the tutor uses, its underpinnings in cognitive and textual theories, and the results of a pilot study (1992-1993).

14. SUBJECT TERMS
Computer-mediated intentional learning environments; Critical literacy; Intelligent tutoring systems; Thinking frames; Strategy acquistion

15. NUMBER OF PAGES
23

16. PRICE CODE

17. SECURITY CLASSIFICATION	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

This paper gives an overview of R-WISE (Reading and Writing in a Supportive Environment). This software is an adaptive tutoring environment that fosters (1) verbal reasoning skills, (2) strategy acquisition for composition, and (3) the metacognitive awareness necessary to manage the multi-dimensional nature of the writing process.

Many people contributed to the development of R-WISE. The authors express their gratitude to the high school teachers who served as subject matter experts; the programmers who implemented the software; and the research assistants who tabulated the data for the pilot study. We especially acknowledge the generous sharing of time and talent and continued support of the following individuals: Dr. Wes Regian, Senior Scientist for the Intelligent Training Branch of the Armstrong Laboratory (AL/HRTI); Lt.Col. James Parlett, AL/HRTI Branch Chief; Dr. Kurt Steuck, the FST Project Manager; and Ms. Teri Jackson, who oversaw the implementation of R-WISE at ten different sites.

R-WISE: A LEARNING ENVIRONMENT TO TEACH PROSE COMPOSITION

1.0 BACKGROUND AND PURPOSE

1.1 The Fundamental Skills Training Project (FST)

The Fundamental Skills Training Project (FST) is a unique and timely collaboration among the military, business/industry, and the educational community to address one of the most pressing challenges facing our nation: teaching the fundamental skills necessary to participate in a complex, modern society. Of the initial set of three tutors, one (an algebraic word problem solving intelligent tutor) has been completed; a second (a critical literacy tutor) is in the evaluation phase; and a third (a principles of science tutor) is in the development stage. This document elaborates on the critical literacy tutor.

1.2 Critical Thinking and Composition

The national attention focused on the "literacy crisis" addresses a significant and real problem in contemporary America -- the alarming increase in numbers of people who simply cannot read. However, this high visibility for illiteracy in its most egregious forms may mask other issues in "language skills." For example, recent National Assessment of Educational Progress (NAEP) findings suggest a growing inability among young people to perform complex verbal tasks, to draw inferences from text, to detect bias in verbal presentations, to follow multi-level arguments. In other words, NAEP identified a substantial stratum of learners who can read and write at a level of minimal competency (and are therefore not "functional illiterates") but who cannot demonstrate deep understanding, cannot use probabilistic reasoning or draw valid conclusions, cannot distinguish among levels of specificity or forms of evidence, cannot follow implications in text, and in general are prone to oversimplify all but the most basic of verbal tasks.

Deficiencies in composition are especially noteworthy. Most adolescent learners write only on a minimal level of acceptability. Furthermore, their inadequacy is not necessarily a result of poor spelling, vocabulary, grammar, verbal fluency, syntax, paragraphing, or other such production skills. Bereiter and Scardamalia call the form of writing practiced by inexperienced writers **knowledge telling** (1987, p. 5). For these two noted researchers, knowledge telling is characterized by (1) a simple task execution involving only limited planning and minimal mental engagement, (2) production methods adapted from oral abilities, (3) organizational patterns based on free-association or simple narration, (4) development that contains large chunks of irrelevant information or elaborations based on simple descriptions, and (5) an egocentric perspective. The antithesis, **knowledge transformation**, as practiced by good writers, is characterized by (1) guided planning and situational diagnostics, (2) rich mental representations of text possibilities for a wide range of scenarios, and (3) a robust "executive control program" for allocating mental resources and for handling the tremendous cognitive load of verbal composition.

R-WISE addresses these issues of critical literacy and teaches the use of language as a vehicle for critical thinking. Though we draw our philosophy as much from informal logic (on the rhetoric side) and problem-solving (on the cognitive science side), we also draw (particularly in the area of pedagogy) from the whole-language movement. The goal of the project is to design, develop, field, and evaluate an intelligent tutoring system to teach critical thinking skills, as manifested in reading and writing.

2.0 COMPUTERS AND THE TEACHING OF WRITING

2.1 Historical Approaches

The notion of using computers to facilitate the teaching of writing has been around for quite some time (Bangert-Drowns, 1993). In general, one can see two broad trends in the early efforts: (1) research into whether or not word processing alters composing, and (2) various forms of parsers and natural language processing for detecting flaws in text (such as the many separate programs in the Writer's Workbench®). Both efforts have produced only limited results because both technologies -- at their roots -- are intended to enhance productivity rather than facilitate cognition. In short, they are just not the type of tool -- as delineated by Gavriel Salomon (1991 and 1993) -- to produce a lasting gain in performance, once the tool has been removed.

2.2 R-WISE as a Learning Environment

R-WISE encourages students to practice composition in a computer-mediated environment, where the specially designed software acts as a **procedural facilitator**. This term is used by

Vygotsky (1978) to explain the cognitive mentoring and developmental dynamics that occur between master and apprentice and between peers during collaboration. Salomon (1988) and Zellermayer (1991), among others, use the term to suggest that the computer can serve as a peripheral brain for the fledgling student and provide the scaffolding that allows the novice to practice the more robust problem-solving behaviors of an expert. R-WISE serves as a **cognition facilitator** for critical thinking by:

- Easing demands on short-term memory and helping to focus attention on strategically important aspects of writing;

- Guiding the inculcation and self-initiation of higher-order processes (metacognition) which the novice writer is unlikely to activate without prompting;

- Explicitly modeling strategic intellectual processes so that the fledgling student avoids what Collins & Gentner (1980) have termed "downsliding," or becoming increasingly entangled in lower and lower levels of mental actions, finally concentrating all mental energy on such things as spelling, grammar, and sentence construction to the exclusion of larger concerns in the process.

3.0 SOFTWARE COMPONENTS

R-WISE consists of a suite of computerized "tools" to aid ninth-graders in learning the art of prose composition. We selected the tools based on (1) their potential to represent components of the writing process as a visual algorithm and (2) their ability to model robust, expert behaviors for the student. A simple model for the composing process that has gained wide acceptability in pedagogy depicts writing as having three central phases or stages: (1) Prewriting or invention, (2) Writing or drafting, and (3) Revision or editing. The three software components showcased in this paper mirror this partitioning of the process.

3.1 Cubing: The Prewriting Tool

Information is not knowledge, just as understanding the content of a piece of prose is not equivalent to understanding and using the concepts presented in a text. This tool is called "Cubing" because it is based on a graphical representation of complex mental operations. "Cubing" helps the student to draw inferences and to elaborate on the basic concepts being developed in a piece of emergent text. The tool helps to bootstrap comprehension by modeling a process for (1) extracting meaning, (2) formulating inferences, interpretations, and re-interpretations, and (3) engaging passive knowledge and connecting it with the current stimuli.

3.2 Idea Board: The Drafting Tool

This tool (called Idea Board) mediates a major cognitive shift in the writing process -- from the macro structures of thought to the micro structures of socially accepted, connected prose. Using a visual algorithm, the tool models robust, expert behaviors for writing a first draft. By foregrounding activities at appropriate times and relegating others to less prominence, the tool teaches the student to manage the cognitive load of composition.

3.3 Triple Vision: The Revision Tool

This tool helps the student to "re-see" a completed draft at three different levels of focus. Editing, as fostered in this tool, refers to substantial changes, such as improving style, adding to or subtracting from the content, rearranging parts, or completely rewriting. These more global, deep-structured editing acts are associated with higher-order cognitive skills (e.g., discerning patterns in bodies of information, exercising judgment, analysis, synthesis). More specifically, Triple Vision contains a number of heuristics for improving both coherence and development.

4.0 INSTRUCTIONAL APPROACH

R-WISE uses a hybrid paradigm for interactive instruction. Part of the guidance comes from adaptive tutoring using traditional AI formalisms and part of the teaching comes from the powers of reification (or representing complex processes as manipulable objects on the computer screen). Tools in this suite (1) accommodate deficiencies and thereby reduce frustration for a weak writer, (2) emulate some of the crucial functionality of paper copy, (3) enrich the environment and thereby sustain motivation, and (4) model robust behaviors.

While each of the three adaptive tools being considered concentrates on a specific cluster of skills, all three have a unified method for delivering layered instruction and a canonical architecture for the software and the interfaces. Figure 1 guides the discussion for the next five subheadings.

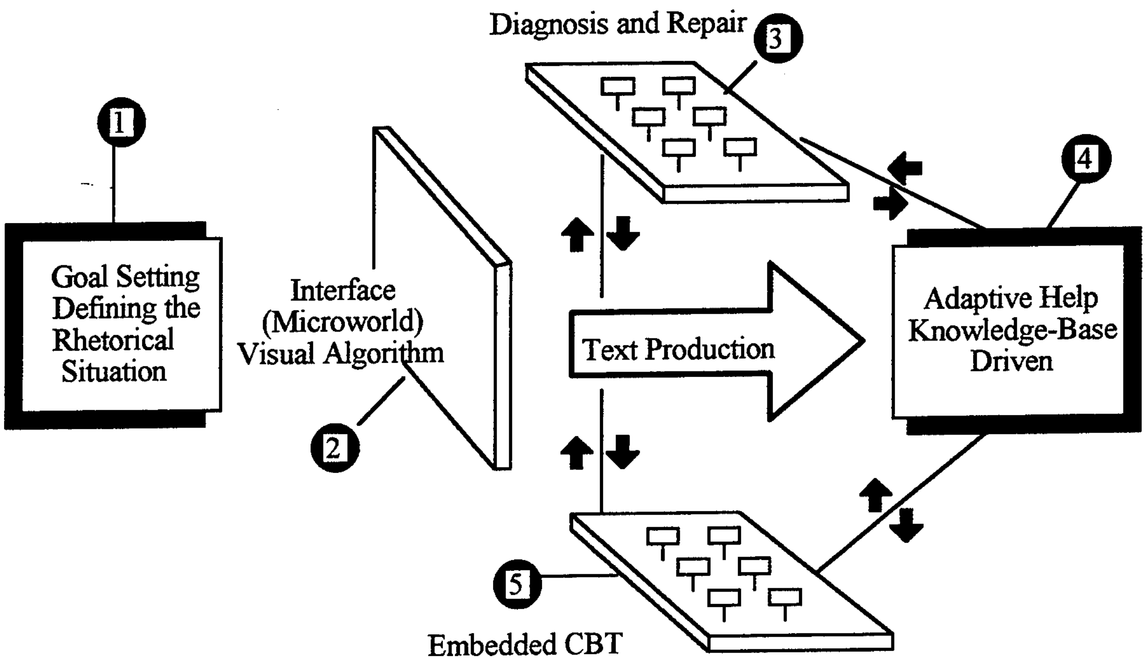

Figure 1: System Overview of Hybrid Tutoring Capabilities

4.1 Setting Goals

(Area 1 of Figure 1) Using a **knowledge-telling** approach, the novice writer views composition as if it were a straightforward exercise in generating ideas through association. For the expert, however, having an explicit, stable set of goals fosters a kind of filtering activity that focuses the task from the outset.

Each of the three cognitive tools handles this concretizing of goals in a slightly different manner. In Cubing, the tool selects from a collection of nine possible readers and nine possible reasons to write, (e.g., write a persuasive piece for a reader who is an expert in the subject matter). The student is then given this combination as a rhetorical situation. Idea Board asks the student to pick from a list the most applicable response to each of four questions: (1) What is your purpose for writing? (2) How will your audience react? (3) What is the best form for this paper? (4) What difficulties will you have with this paper? Triple Vision asks the student to set "sliders" to indicate three dimensions of the reader and three dimensions of the writer (as illustrated in Figure 2).

Not only does this exercise help the novice student focus on an area where she is weak, this preliminary work "sets" the parameters of the adaptive tutor. Each writing environment now has a "frame" or backplane of conditions against which further actions can be evaluated during the remainder of the session on the tool. (If the student changes goals, the frame is also updated.) Table 1 gives the number of combinations (or rhetorical situations) tracked by each of the tools. Clearly, the repertoire is rich, and becomes even richer as these preliminary combinations are conjoined with additional data points drawn from the student's subsequent activities as the writing progresses (as will be illustrated in Table 2).

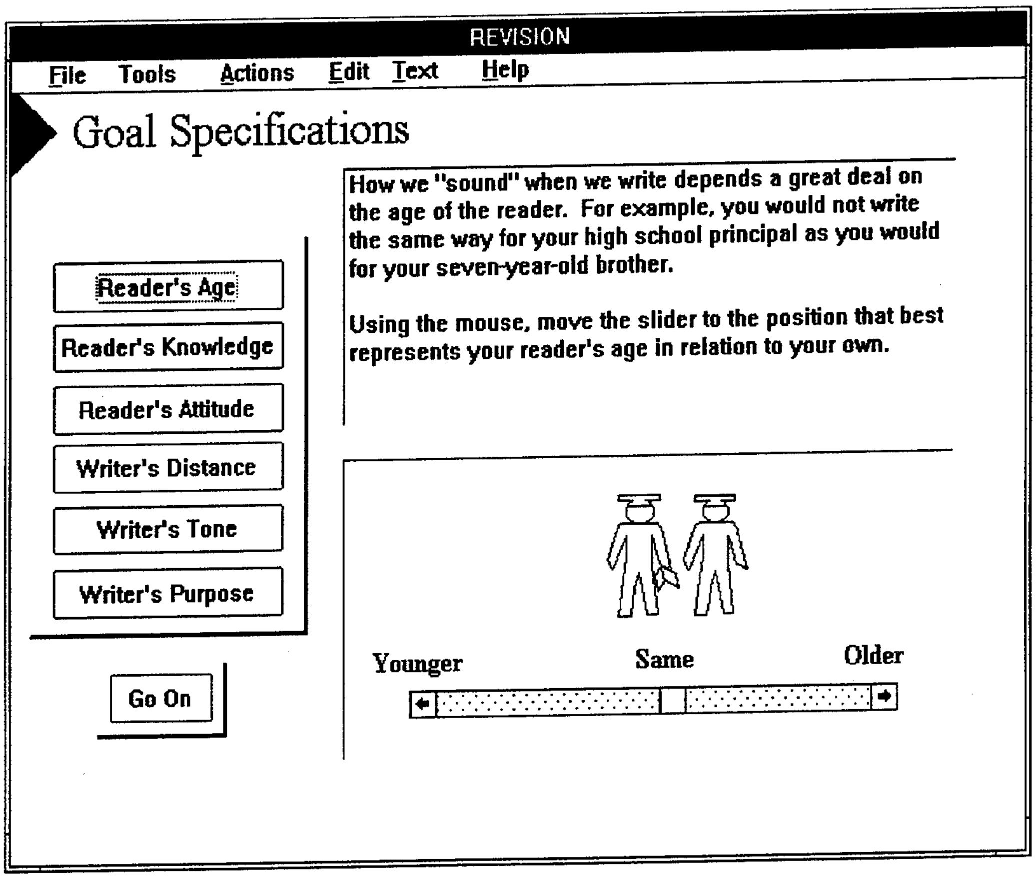

Figure 2: Setting Parameters for System Adaptation

Table 1: Tracking Combinations in the Frame

TOOL	CONDITIONS	COMBINATIONS
Cubing	Reader Profiles (9) Aims or Purposes (9)	81
Idea Board	Purpose (5) Audience (6) Form (6) Difficulties (7)	1,260
Revision	Reader's Age (3) Reader's Knowledge (3) Reader's Attitude (3) Writer's Distance (3) Writer's Tone (3) Writer's Purpose (3)	729

4.2 Visual Algorithms

(Area 2 of Figure 1) The second way in which R-WISE teaches is to reify complex and potentially covert mental operations. Where possible, the interfaces of R-WISE represent visual organizers for specific intellectual processes. As explained by J. H. Clarke (1991, p. 526-7), "[f]rom the standpoint of cognitive theory, graphic frames mimic aspects of semantic memory structures or schemata, that learning theorists believe organize the mind."

For example, Figure 3 shows "Idea Map," an early workspace in Idea Board that encourages structured brainstorming by presenting the student with a visualization of mental manipulations. Given the premise that most of the clients for R-WISE probably have learning preferences that are concrete/visual rather than abstract/language, we provide "objects" for obscure mental actions. Similar to "webbing" -- a paper-and-pencil technique used in the writing classroom -- this thinking frame prods the student to cluster ideas into proto-paragraphs. Working with the "Idea Map" helps the student to recognize and to take control of the intellectual processes foundational to composing.

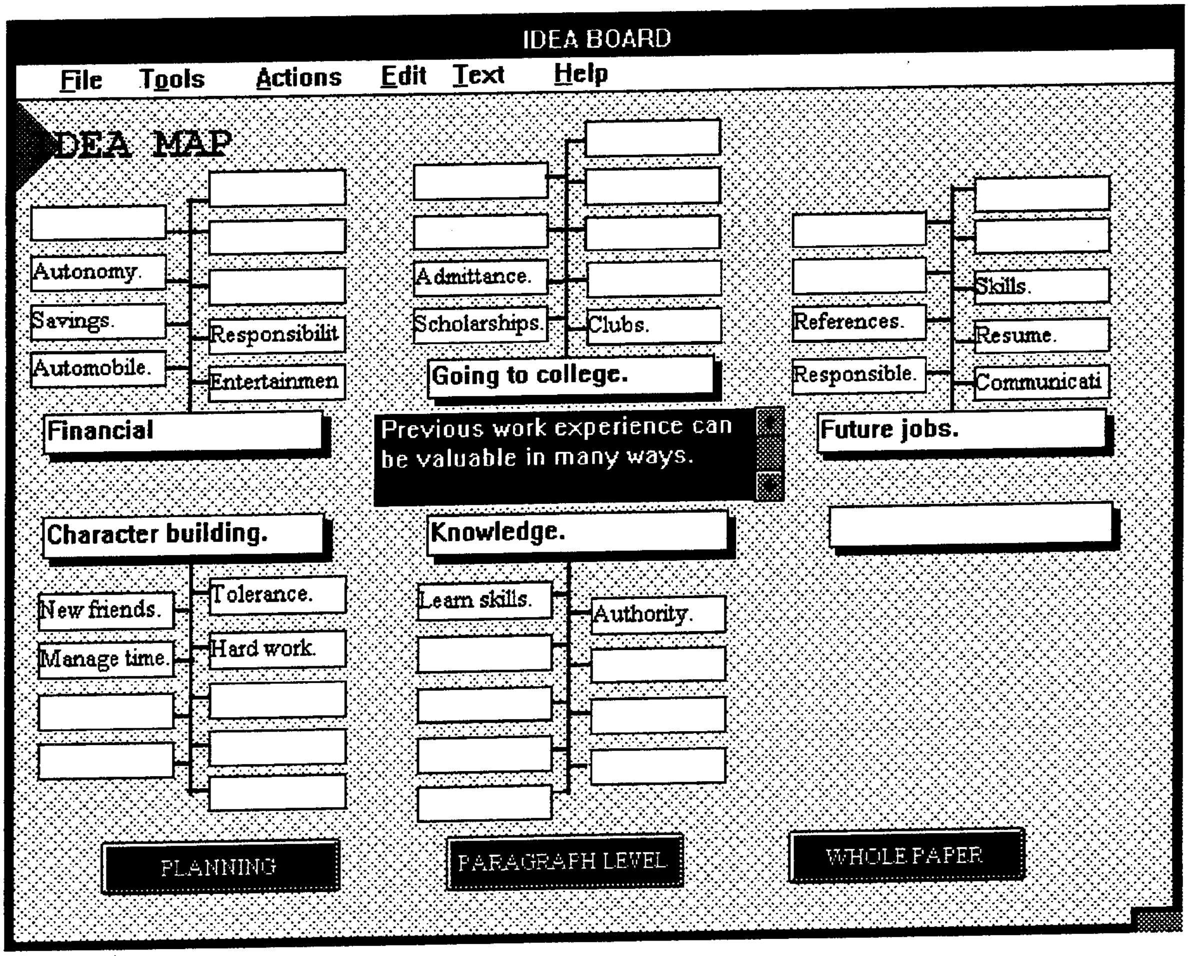

Figure 3: Idea Map Interface from the Idea Board Tool

4.3 Diagnosis and Repair

(Area 3 of Figure 1) Writing is a complex, multi-dimensional activity analogous to a contingency management problem. Only in working through candidate solutions does the nature of the problem become fixed, or even definable. Rather than working in a linear fashion through the model of PLAN - PREWRITE - DRAFT - EDIT, good writers use an opportunistic approach. They constantly measure the emerging text against a set of expectations, while at the same time recognizing and capitalizing on serendipitous gains, weaving these "discovered" possibilities into a new rendition of the overall plan and product.

Unfortunately, text production strategies for novice writers are frail and one-dimensional. Such impoverished capabilities do not lend themselves to interruptions or re-assessments. As evidenced by Bereiter and Scardamalia's research into the writing process for novices, little evidence can be found that weak writers can participate in self-cueing or self-monitoring activities while engaged in the production of text (1987). In fact, the very act of breaking out of their one-dimensional, stream-of-consciousness mode jeopardizes the continued production of text.

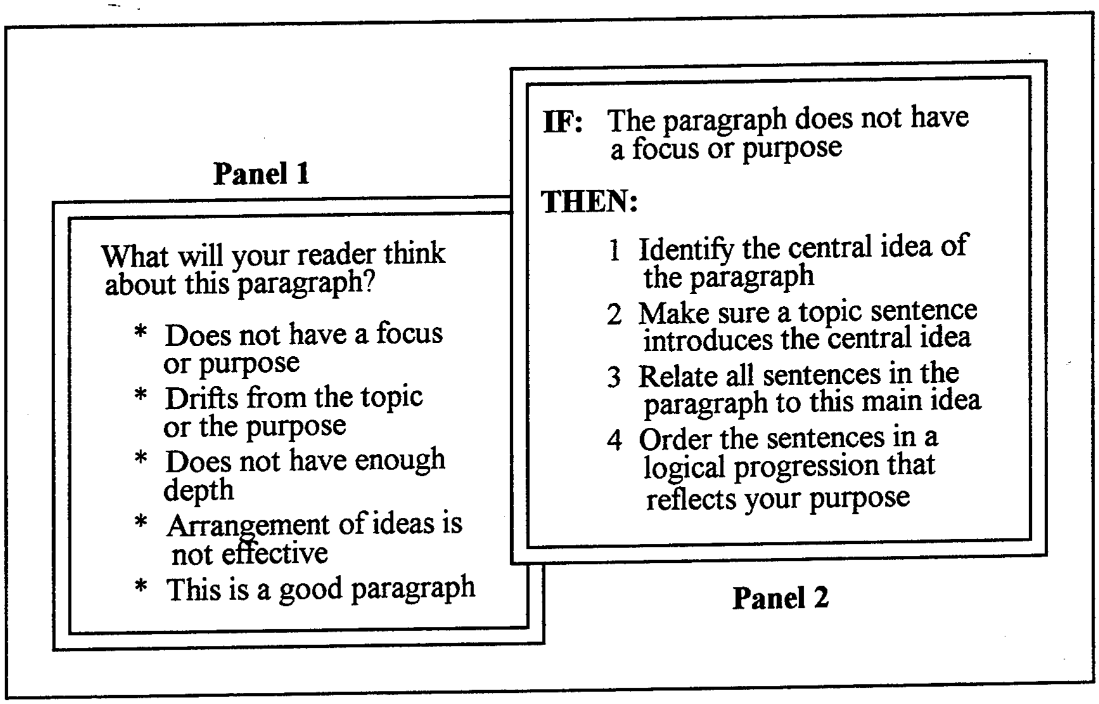

Figure 4: Diagnosis and Repair Prompting for Triple Vision

Diagnosis-and-Repair is an evaluation loop that partners with the student to reduce the cognitive load and encourages the student to enter into an assessment episode. This loop -- essentially modeled after Bereiter and Scardamalia's well-researched CDO (COMPARE, DIAGNOSE, OPERATE) sequence (1987) -- takes a very sophisticated, open-ended problem and pares it down to a manageable set of options for the inexperienced writer.

Succinctly, this facilitator operates (in all three tutors) in the following sequence:

- The student detects a mismatch between the goals (her intentions for writing) and a chunk of text. As a response to this dissonance, the student requests help.

- The system brings up a list of potential problems applicable to the specific sub-task the writer is working on. For example, in Figure 4, the student is reviewing paragraph patterns in the Triple Vision tool and detects an awkward place.

- Asking for help produces the Diagnostics on Panel 1 (Figure 4). Selecting any one of the first four assessments brings up a repair agenda (Panel 2) dealing specifically with that condition. By presenting a limited set of options and by making suggestions (rather than dictating) about ways to improve, the system both engages and challenges the writer at the appropriate level.

Clearly, the lists of options are a form of embedded instruction, and the student probably will come away from extended exposure to any of the three tutors with better content knowledge about what can go wrong at various stages of composition. However, we feel that the more important lesson the student learns is an enriched self-regulatory capacity so that she can move out of the text production mode into a higher-level cognitive activity without disrupting the whole composing process. This ability to suspend operations on one level and to focus mental energies on another is characteristic of the experienced writer (Hayes and Flower, 1980).

4.4 Adaptive Advice

(Area 4 in Figure 1) In the metacognitive stage (diagnosis and repair), the machine partners with the student to develop the sensitivity and awareness necessary to know what is wrong with a prose performance and how to improve the result. Yet, because the diagnostic is performed by the student, there is a potential for a misjudgment. Additionally, if the system is to serve as an intelligent "guide" or "coach," the tool should have a feedback loop to indicate the "reasonableness" of the course of action the student is pursuing, baselined against some known set of criteria.

Adaptive advice adjusts its statements based on an "intelligent" assessment of the situation -- meaning that the software compares the manipulation the student is working on with the conditions of the frame and determines how "correct" these actions are given the circumstances. The resultant, targeted prompts help the student to learn the more subtle aspects of adaptation to audience and purpose. They also help the student to stay on the right track and avoid the frustration of writing text that is later deemed to be inadequate to the task. Cubing, Idea Board, and Triple Vision contain advice that is germane to the focus of the tool. For example, Cubing -- whose domain is prewriting or the invention phase of writing -- prods the student to generate ideas. Triple Vision, on the other hand, contains advice to aid in the assessment of such things as coherence, introductory and concluding paragraphs, whole-paper arrangement, paragraph structures, and effectiveness of individual sentences. Figure 5 shows how adaptive advice is displayed to the student. In this particular case, the student is working in Cubing and is generating ideas to include in a job application. The reader is classified as an "evaluator," and the aim is "to persuade." The student is trying to elaborate on the topic of "previous work experience" when she asks for strategic advice.

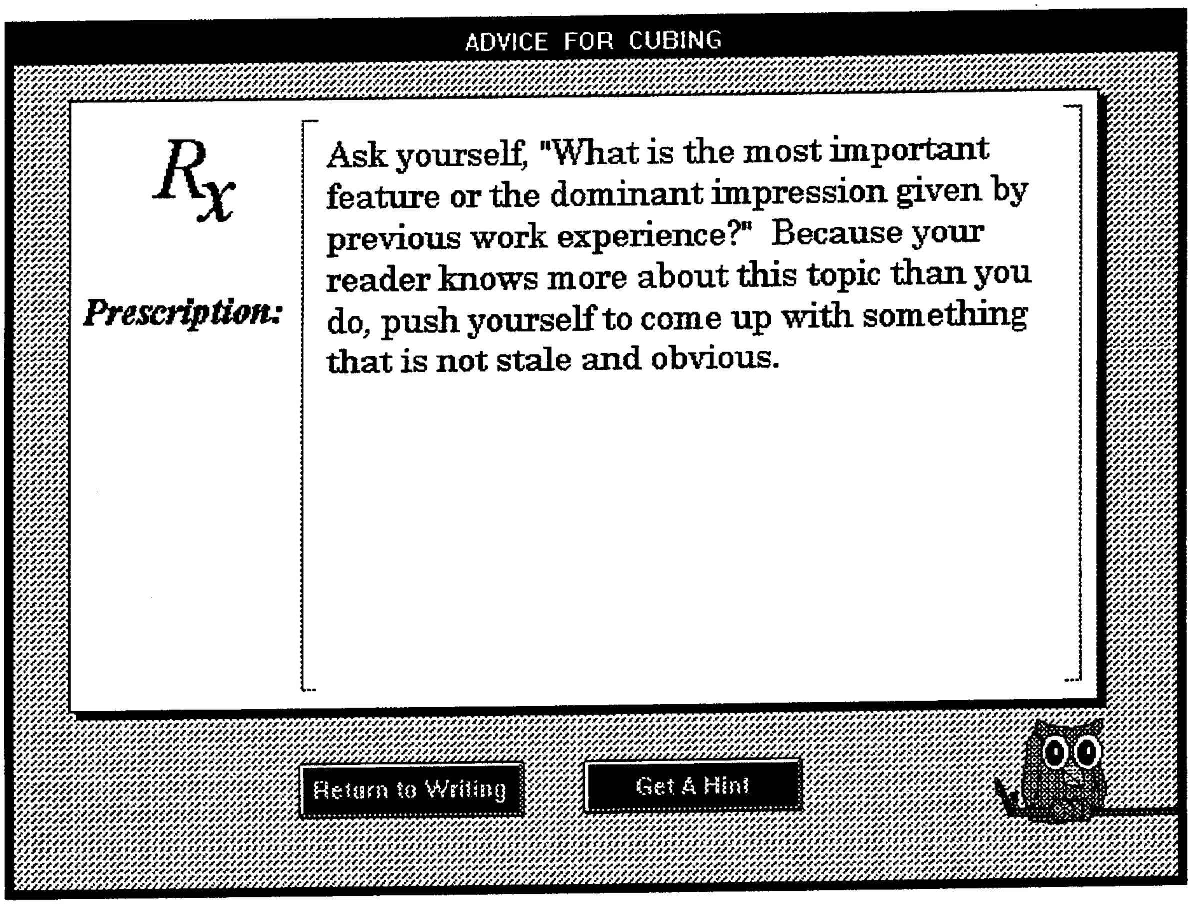

Figure 5: Example of Situation-Specific Adaptive Advice for Cubing

In all the intelligent tools, adaptive help is generated through a kind of triangulation, based on the rhetorical situation (frame conditions of audience and purpose) and the moves made by the student in the micro-world or visual workspace. Monitoring the combination of rhetorical situation and place in the writing process creates a rich representation for accessing instructional statements. Table 2 shows the number of instructional situations captured in each tool. Because of the large numbers, in the current version of R-WISE we have implemented a pruning algorithm that weighs the various elements going into the instructional situation and generates a manageable set of instructional statements. For example, the student, having written a topic sentence (1) for a paragraph of factual detail, (2) intended for an audience at a distance from the writer, (3) younger than the writer, and (4) less knowledgeable than the writer might be prompted to consider whether or not the advanced organizer (topic sentence) is adequate for the purpose and the audience.

Table 2: Generating Adaptive Help

TOOL	FRAME COMBINATIONS	DIAGNOSTIC CHOICES	INSTRUCTIONAL SITUATIONS	ADVICE STATEMENTS
Cubing	81	18	1,458	72
Idea Board	1260	18	22,680	50
Revision	729	27	19,683	153

4.5 <u>Just-in-Time-Tutoring</u>

(Area 5 in Figure 1) While designing R-WISE, we carefully planned how to integrate the tutor into a year-long ninth-grade curriculum. As currently fielded, the tutor takes up about 20-25% of the course. The production skills necessary for writing (e.g., topic sentences, paragraph patterns, conclusions and introductions, and other rhetoric fundamentals) are taught in the classroom, not on the computer. This is a deliberate decision. To act as an accelerator, the computer has to support the process of literacy. Interrupting the process to teach the enabling skills (1) mixes levels, styles, and purposes of instruction, (2) creates breaks in the train of thought from which the student cannot recover, and (3) results in a fairly unexciting electronic workbook.

While production skills and metacognitive skills are not interchangeable, they are correlated in that they must occur simultaneously in expert behaviors. After diagnosing a problem and getting a repair, the student may still be at a loss as to what to do. Recognizing that students may need reminders of materials covered in class, we have embedded a CBT component in R-WISE that provides "hints" upon request. This instruction (similar to a high-end form of context-sensitive help) is analogous to a job aid in that it gives a synoptic overview of concepts presented in class. Its purpose is to serve as a reminder or a refocusing prompt for the student rather than a full-blown instructional component.

All three tools have a just-in-time-tutoring (JITT) module for each diagnostic choice they present. Each unit is terse and highly visual, representing fundamentals of composition with conceptual maps and pseudo-animation. Figure 6 gives a sample of a JITT interface.

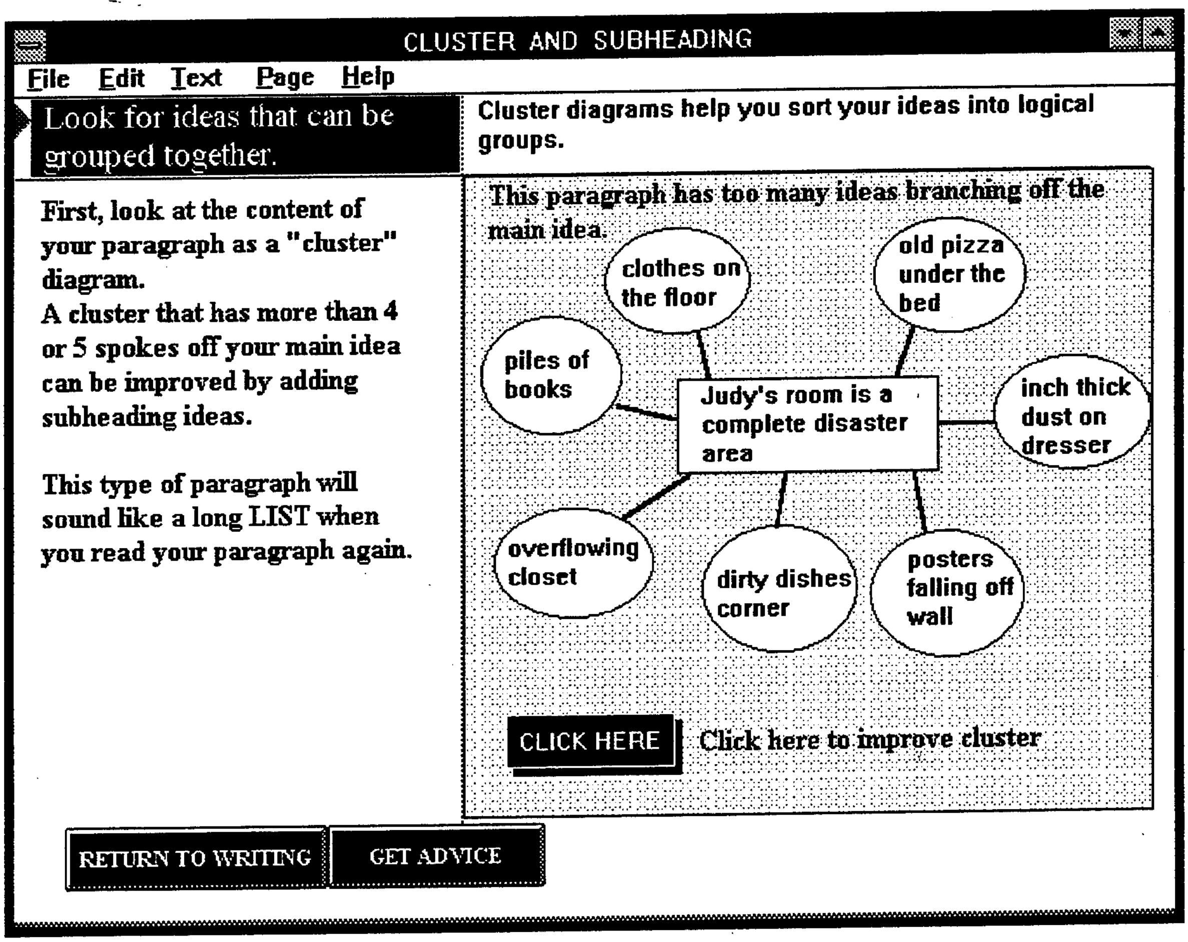

Figure 6: Example of a Single Screen from a JITT Module

5.0 PILOT STUDY AND FUTURE PLANS

A pilot version of R-WISE was field-tested during academic year 1992-1993. A San Antonio high school with a population of approximately 650 ninth-graders used various components of the system over a nine-month period. In working with this Beta-test site, we were interested in a variety of research questions, including issues of design and user acceptance. We used several instruments to measure learning outcome, but only the results of the writing sample are presented here.

A second high school, within the same district and demographically similar to our pilot site, was selected as a control. Two equivalent writing prompts were devised, and one was given in January as a pre-test; the other was given in May as a post-test. We devised a rubric for holistically scoring the papers on a 1 to 6 scale and then had the approximately 2,200 samples professionally evaluated. The standard procedure of having two readers examine each paper was used. Inter-rater reliability was .79 -- meaning that, for close to 80% of the writing samples, a team of two readers gave the paper the same number during independent evaluation. This is a rigorous standard for reliability. The more common practice in writing sample scoring is to declare continuous numbers (e.g., 4 and 5 or 3 and 2) reported by two readers as being in agreement. Had we used this method of determining agreement, our inter-rater reliability would have approached .92.

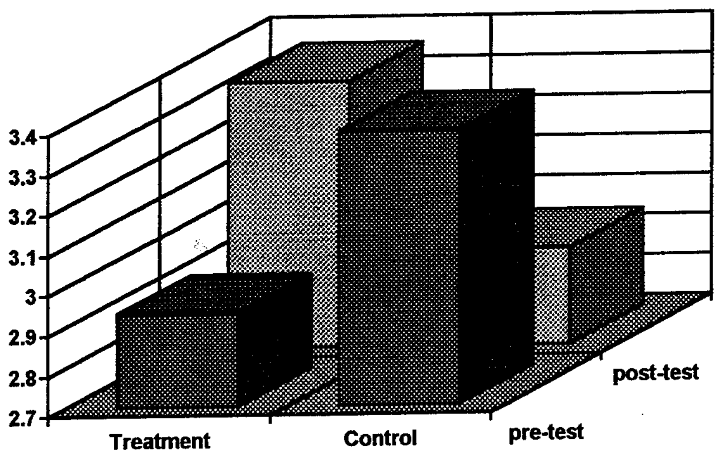

Figure 7: Mean Scores for Control and Treatment on Pre and Post Test

The differences in means on the pre-test and post-test for both control and treatment groups were deemed statistically significant using t-tests and are given in Figure 7. We are encouraged by the approximately 8% gain accomplished by the treatment group, but are cautious in our interpretations given that the software was in a Beta version during the pilot study. A more finished version of R-WISE is now being used by ten test sites in five different states. We hope to get even more of an effect from this production version of the software.

REFERENCES

Bangert-Drowns, R. L. (1993). The word processor as an instructional tool: A meta-analysis of word processing in writing instruction. Review of Educational Research, 63(1), 69-93.

Bereiter, C. and Scardamalia, M. (1987). The Psychology of Written Composition. Hillsdale, NJ: Lawrence Erlbaum Associates.

Clarke, J. H. (1991). Using visual organizers to focus on thinking. Journal of Reading, 34(7), 526-534.

Collins, A.M. and Gentner, D. (1980). A framework for a cognitive theory of writing. In L.W. Gregg and E. Steinberg (Eds.), Cognitive Processes in Writing, (pp. 51-72). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hayes, J.R. and Flower, L.S. (1980). Identifying the organization of writing processes. In L. W. Gregg and E. Steinberg (Eds.), Cognitive Processes in Writing, (pp. 3-30). Hillsdale, NJ: Lawrence Erlbaum Associates.

Salomon, G. (1993). On the nature of the pedagogical tool: The case of the writing partner. In S.P. Lajoie and S.J. Derry (Eds.), Computers as Cognitive Tools, (pp. 179 - 96). Hillsdale, NJ: Lawrence Erlbaum Associates.

Salomon, G., et al. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. Educational Researcher, 20(3), 2-9.

Salomon, G. (1988). AI in reverse: Computer tools that turn cognitive. Journal of Educational Computing Research, 4(2), 123-139.

Vygotsky, L. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

Zellermayer, M., Salomon, G., Globerson, T., and Givon, H. (1991). Enhancing writing-related metacognitions through a computerized writing partner. American Educational Research Journal, 28(2), 373-391.